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# LIVING LIGHT: BIOLUMINESCENCE

## The Historical David

## Total Depravity?

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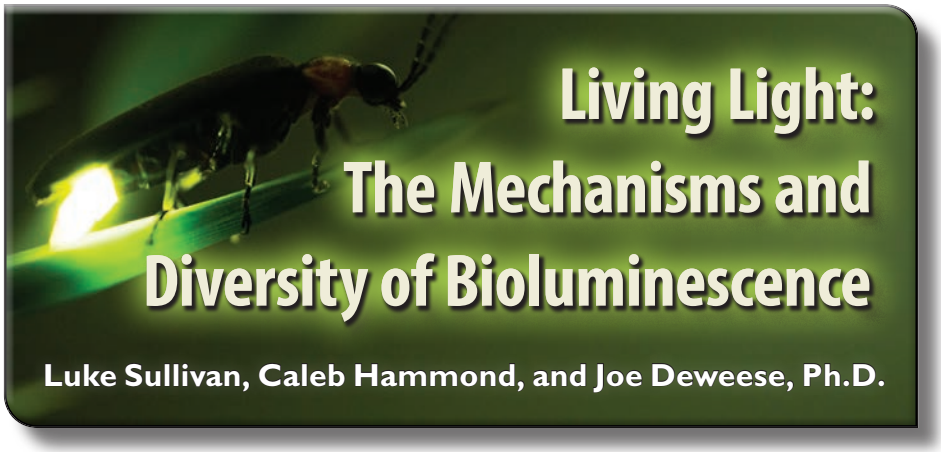

# Living Light: The Mechanisms and Diversity of Bioluminescence

Luke Sullivan, Caleb Hammond, and Joe Deweese, Ph.D.

*Article In Brief...*

**Bioluminescence is a fascinating feature of many different organisms in nature. These organisms have the ability to generate light using various complex systems such as luciferin and luciferase or fluorescent proteins. Interestingly, the unique forms of bioluminescence spread across diverse species require evolutionists to assume multiple evolutionary origins for these systems. The elegant design of these systems and the range of organisms using them is better explained by design than by evolutionary accident.**

[EDITOR'S NOTE: The following article was co-authored by AP auxiliary staff scientist Dr. Joe Deweese and two of his talented undergraduate research assistants, Luke Sullivan and Caleb Hammond, both of whom are former Apologetics Press camp attendees. Dr. Deweese holds a Ph.D. in Biochemistry from Vanderbilt University and serves as Professor of Biochemistry and Director of Undergraduate Research at Freed-Hardeman University.]

## INTRODUCTION

On a summer night, one of nature's most captivating sights is the flickering of fireflies (Figure 1). These glowing insects, like many other organisms, exhibit bioluminescence—the ability to produce light through chemical reactions in their bodies. Bioluminescence can be found in various creatures, from land-based fungi to ocean-dwelling bacteria. In fact, approximately 76% of all marine organisms are bioluminescent.[1]

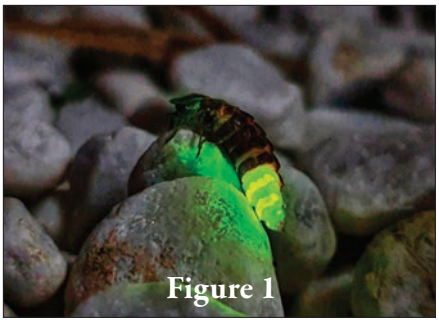

Figure 1

Bioluminescence occurs in three main ways. The first mechanism is the **luciferin-luciferase** system, which involves molecular oxygen, a light-producing molecule called luciferin, and an enzyme called luciferase. Luciferase helps oxygen react with luciferin, which leads to light production (Figure 2).[2] While

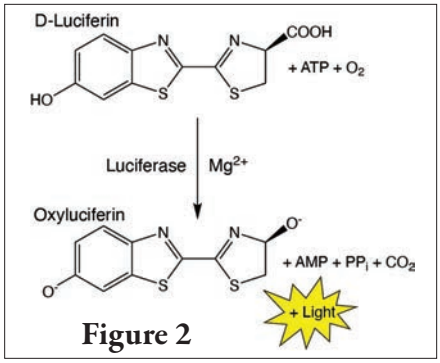


Figure 2

the structures and chemical compositions of luciferins and luciferases vary across species, many organisms, such as fireflies and marine plankton, use a form of this system (Figure 3).[3]

The second form of bioluminescence uses **fluorescent proteins**, which absorb one wavelength of light and emit another. While the green fluorescent protein (GFP) from jellyfish has greatly benefitted the scientific community, its mechanism is different from other luminescent proteins.[4] The chromophore, the part that absorbs and re-emits light, is located in the primary structure of the protein, which depends upon its amino acid sequence.[5] Researchers have modified GFPs to use in research applications, altering the wavelengths of light that are absorbed and emitted.

Finally, there are the **photoproteins**. These molecules are similar to luciferin in that they react with oxygen to emit light, but the reaction does not require a luciferase. Interestingly, photoproteins and GFP have been discovered as working together in jellyfish.[6] It is unclear

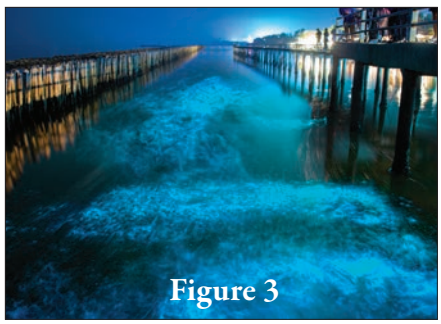

Figure 3

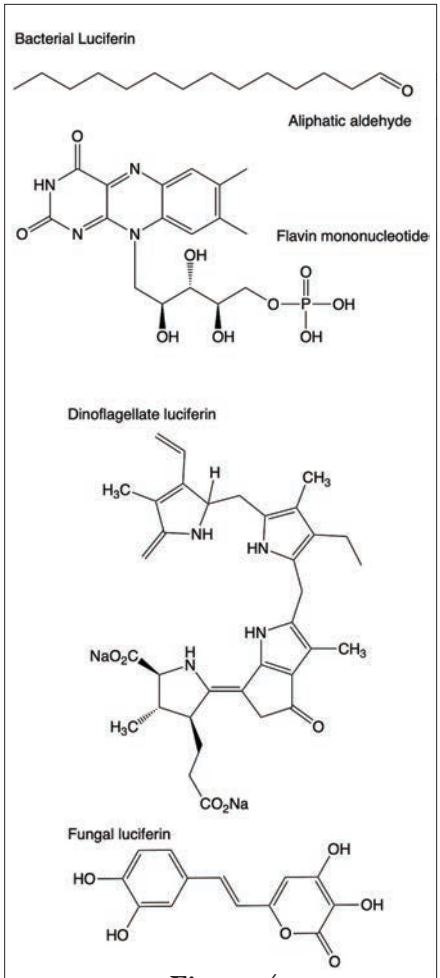

**Figure 4**

how widespread photoproteins are among living organisms.

In some cases, bioluminescence is found in organisms that do not generate the light but instead exist in a symbiotic relationship with bioluminescent bacteria. For example, the Anglerfish produces light through a specialized organ, called the esca, that houses bioluminescent bacteria.[7] These bacteria use a luciferin-luciferase type system, but it is very distinct from that found in fireflies and other eukaryotic organisms. The remainder of this article aims to explore examples of the diversity of the luciferin-luciferase bioluminescent systems.

## DIVERSITY OF LUCIFERIN-LUCIFERASE SYSTEMS

LUCIFERIN-LUCIFERASE systems vary significantly across organisms. The term "luciferin" broadly refers to any molecule that reacts with oxygen to generate light. Examples of different luciferins are shown in Figure 4. Organisms must not only produce luciferin but also create enzymes to regulate its production and control the timing of light production.[8]

There is also great diversity in luciferases.[9] Examples of bacterial and eukaryotic luciferases are shown in Figure 5. The amino acid sequences of these enzymes are highly diverse, illustrating that these enzymes are structurally unique across species.

Some evolutionary scientists suggest that luciferases evolved independently in different organisms. For example, the luciferase system in fireflies is believed to have evolved separately from the marine systems. Each system has unique biochemical pathways, supporting the idea that these systems are highly specialized.[10]

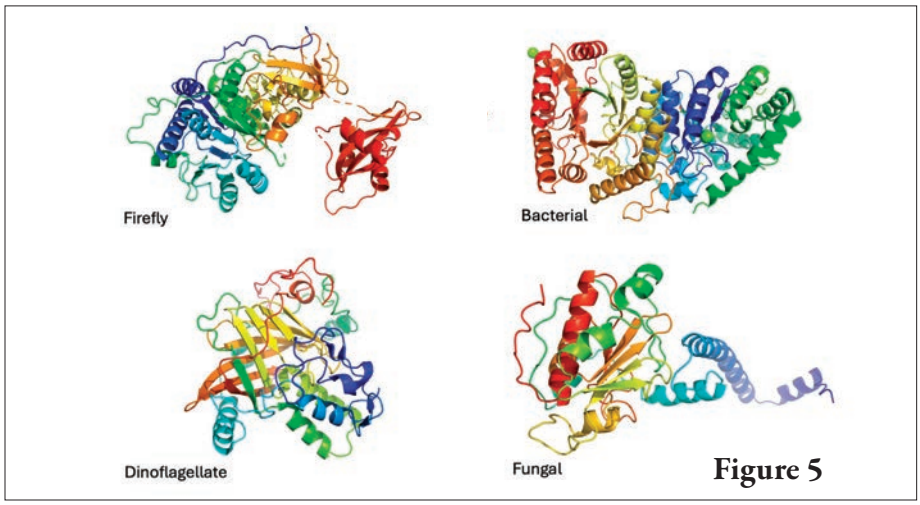

**Figure 5**

## BACTERIAL LUCIFERIN-LUCIFERASE SYSTEM

THOUGH bacteria are simple organisms, their bioluminescent systems are complex. Bioluminescent bacteria contain genes that encode the proteins necessary for light production. Some evolutionists believe these genes evolved independently in many species, while others argue that they spread through horizontal gene transfer (i.e., the ability of some organisms to transfer genetic information to other organisms).[11]

In bacteria, two proteins, LuxA and LuxB, form a complex called LuxAB. This complex converts aldehydes into acids, using $FMNH_2$ as an electron source. There is debate over the precise nature of the chemicals involved in the reaction, but long-chain aldehydes are generally accepted as the substrates.[12] Several other reactants and genes regulate the light's intensity and other aspects of the system.[13] Despite the continued exploration of bacterial bioluminescence, much remains to be discovered about how all the components work together.[14]

## FUNGAL LUCIFERIN-LUCIFERASE SYSTEM

BIOLUMINESCENT fungi, which can be found worldwide, have fascinated scientists for centuries. Approximately 80 species of glowing fungi have been identified (see Figure 6 for an example). However, it was only in 2015 that the luciferin responsible for fungal bioluminescence was discovered. Researchers found that the molecule 3-hydroxyhispidin acts as luciferin in fungi, a molecule also found in some plants.[15]

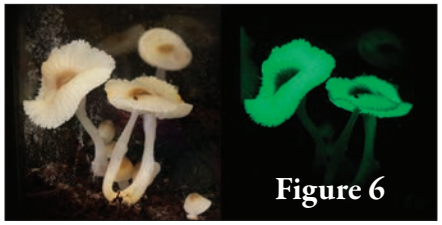

Figure 6

Fungal bioluminescence seems to be a by-product of metabolism, as the light is constantly produced. The intensity of the light varies with the time of day, suggesting a connection to circadian rhythms.[16]

The process of light production in fungi involves two steps. First, a precursor molecule, hispidin, is converted into 3-hydroxyhispidin by an enzyme. This luciferin is then activated to produce light. Although researchers are still working to fully understand the genetic mechanisms behind this process, the general reaction has been established.[17]

## DINOFLAGELLATE LUCIFERIN-LUCIFERASE SYSTEM

DINOFLAGELLATES, tiny single-celled organisms that are a type of phytoplankton, produce one of the most stunning forms of bioluminescence and are responsible for the glowing ocean waters often observed at night (Figures 3 and 7). Unlike other systems, dinoflagellates produce light in specialized organelles called scintillons, which contain luciferin, luciferase, and sometimes a protein that binds to luciferin.[18]

The luciferin in dinoflagellates is structurally similar to chlorophyll, the pigment that helps plants photosynthesize. While the exact structure of luciferin in most dinoflagellates is still unknown, the luciferin from *P. lunula* has been studied extensively and is thought to react with the luciferase of other dinoflagellates. The entire system is regulated by the day-night cycle. In some species, scintillons are destroyed at dawn and recreated at dusk, while in others, the molecules are simply relocated to different parts of the cell.[19] Dinoflagellates also have Luciferin Binding Protein (LBP), which is suspected to hold onto the luciferin under normal conditions and release it when the acidity of the cell changes. However, the exact function and mechanism is not known.[20] Though much remains unknown about the function of dinoflagellate bioluminescence, it continues to intrigue scientists for its complexity and beauty.

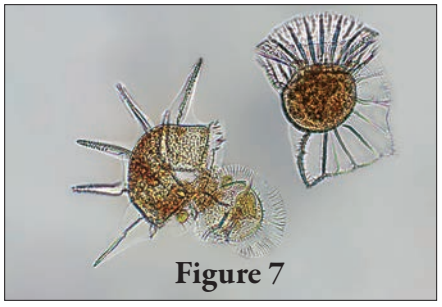

Figure 7

## KEY OBSERVATIONS AND REFLECTIONS

THE diversity among bioluminescent organisms is remarkable, particularly within the luciferin-luciferase systems. Each organism has its own specific luciferin and luciferase, which are not interchangeable between different groups of organisms (e.g., bacterial luciferin cannot substitute for fungal luciferin). Furthermore, the luciferin-luciferase mechanism is dependent upon several components, including genetic information, light-producing luciferin, luciferase enzyme, oxygen, various cofactors, and environmental conditions. Considering the immense diversity and intricate complexity, we must ask a fundamental question: how did these organisms develop this ability to produce light? There are only two options: unguided evolution or intentional design.

Within the evolutionary framework, there are a few postulated possibilities. First, bioluminescence could have originated from an ancestral organism with a primitive luciferin-luciferase system, which evolved into the diverse systems we see today. However, the vast diversity between systems makes it difficult to attribute them all to a common ancestor.[21] Thus, most evolutionary scientists propose that these systems evolved independently in different organisms multiple times![22] Again, however, this is problematic. The statistical probability of this complex system evolving one time is low enough; the likelihood of these mechanisms arising across **all** bioluminescent organisms is practically null.

Therefore, intentional design is the best explanation for the origin of this diverse, complex phenomenon. And because that Designer must be supernatural in order to invent nature, and because the Bible must be the work of a perfect Being in Whom is no flaw, we can humbly and confidently join the Psalmist in professing that all of creation is "the work of [the LORD's] fingers," including this fascinating mechanism of bioluminescence (Psalm 8:3).[23] Furthermore, let's praise Him because the same God who designed the glowing dinoflagellates is "mindful" of us (v. 4). As verse 9 so beautifully says, "O LORD, our Lord, how excellent is Your name in all the earth!"

## CONCLUSION

BIOLUMINESCENCE represents a diverse set of mechanisms in a broad spectrum of organisms. Even within the mechanisms known as "luciferin-luciferase" systems, the degree of diversity is staggering. The **natural** origin of these mechanisms would require multiple evolutionary miracles in order to develop the genes and control mechanisms needed to carry out these functions. These complex systems and their elaborate control systems are best explained by means of a supernatural Creator.

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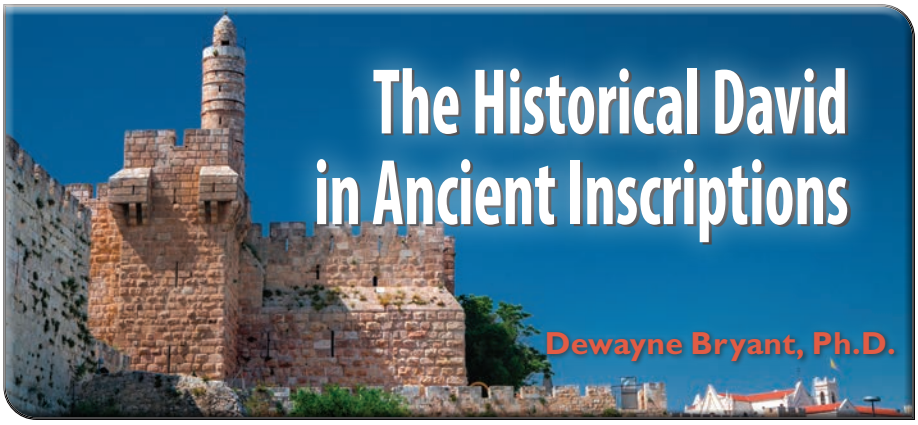

# The Historical David in Ancient Inscriptions

Dewayne Bryant, Ph.D.

DAVID is one of the most significant figures in the Bible. He rose to power from obscurity, surviving repeated attempts on his life and later carving out a prominent kingdom in the Levant. His adventures have prompted television adaptations and inspired movies. His psalms have encouraged and comforted millions of believers for thousands of years. His moral failures have served as cautionary tales warning readers about the disastrous consequences of yielding to temptation.

Christians may hear claims that David is no more real than the legendary King Arthur. As with many other biblical persons, the king has come under assault by those who would consign him to the realm of legend, if not fiction. Critics known as "biblical minimalists" question the historical value of the Bible, generally dismissing all of the claims made by the text unless they can be corroborated by indisputable physical evidence. To them, David and his son Solomon were nothing more than a couple of petty chieftains occupying a tiny piece of hill country. Two famous monuments offer evidence that refutes popular attempts to deny the historicity of David and his kingdom.

The first artifact is the Mesha Stele. This black basalt victory monument commemorates Moab's successful rebellion against the Northern Kingdom of Israel around 850 B.C. Discovered in Dhiban, Jordan in 1868, the Mesha Stele records the achievements of the Moabite king Mesha. This monarch established his capital city at Dibon, asserted his independence from the northern kingdom of Israel after Ahab's death, defeated the Israelite army, and captured or reclaimed several cities under Israelite control. The inscription includes several details that align with the biblical account in 2 Kings 3, as well as numerous references to biblical figures, including Omri, the tribe of Gad, and the covenant name of God, Yahweh.[1]

The Mesha Stele refers to the "house of *dwd*," which scholars have interpreted as the "House of David." The renowned epigrapher André Lemaire (among others) reads the inscription this way.[2] The phrase is a reference to the Southern Kingdom of Judah ("house" meaning "dynasty") and thus identifies David as the founder of the ruling dynasty at the time. Although the reference seems straightforward, biblical minimalists have proposed alternate interpretations. One suggestion is that the term could refer to an as-yet-undiscovered "temple of *Dwd*,"[3] while another posits that the word *dwd* refers to an otherwise unknown deity named Dod.[4] Others claim that the phrase refers to a town[5] or city-state.[6] These suggestions have no supporting evidence, and most members of the scholarly community have dismissed them.[7]

Biblical minimalist Philip Davies argued that the term *dwd* could be translated as "beloved," "uncle," or "kettle," calling these suggestions more "plausible" than translating the term as the name David.[8] The vast majority of scholars roundly disagree with Davies' bizarre suggestion. The late Anson Rainey, a giant in the academic field of ancient epigraphy (the study of ancient inscriptions), stated that Davies was an "amateur" in this area who could "safely be ignored."[9]

The second significant mention of the historical David is found in the Tel Dan inscription, which was discovered in 1993 in excavations at the biblical city of Dan. Surveyor Gila Cook, working under the renowned Israeli archaeologist Avraham Biran, discovered the first fragment of the inscription by chance. She noticed it on a stone fragment from a monument smashed in antiquity and reused as building material for a wall outside the city gate. Efforts to locate additional fragments uncovered two more pieces in the summer of 1994.

The Tel Dan inscription is one of the most significant discoveries in the history of biblical archaeology. It appears to have been authored by Hazael of Aram-Damascus (842-796 B.C.), although his name does not appear in the inscription.[10] Some of the text is damaged, but the most significant portion may be reconstructed as, "[I killed Jeho]ram son [of Ahab] king of Israel, and [I] killed [Ahaz]yahu son of [Jehoram kin]g of the House of David." This interpretation fits with the biblical timeline, although the Bible says Jehu was responsible for the demise of the two monarchs (2 Kings 9:14-28). Given that ancient kings tended to exaggerate or even propagandize their accomplishments, Hazael

likely attempted to claim credit for Jehoram's and Ahaziah's deaths. André Lemaire points out that at least one Assyrian king did something very similar, taking credit for killing someone when another source ascribed the deed to a group of Assyrian nobles.[11] This is just one of several such examples known to scholars.[12] Hazael was neither the first nor the last politician to take credit for someone else's work.

At a time when skeptics in academia had made significant attacks on the historicity of biblical figures, the Tel Dan inscription helped establish David's existence as a fact of history. It is significant enough that even Israeli archaeologist Israel Finkelstein, who often displays considerable skepticism toward the Bible's reliability, would write, "The mention of the 'House of David' in the Tel Dan inscription from the ninth century B.C.E. leaves no doubt that David and Solomon were historical figures."[13] Elsewhere, he says, "the Tel Dan inscription provides an independent witness to the historical existence of a dynasty founded by a ruler named David, from just a few generations after the era in which he presumably lived."[14]

The "House of X" (with "X" representing the name of a dynasty's founder) was a common way of referring to Semitic kingdoms in the early first millennium B.C. In contemporary examples, Assyrian records referred to the Northern Kingdom as the "House of Omri" for well over a century when the Omride dynasty held power in Israel. Additional examples of the same practice appear in ancient Aram and Babylon.[15] Still other examples include the North Syrian kingdom of Arpad (the "House of Agusi") and the kingdom of Damascus (the "House of Hazael").[16] The Mesha Stele and Tel Dan Inscriptions follow standard practice in their references to the Southern Kingdom and the Davidic dynasty.

Attempts to interpret the "House of David" as anything other than the kingdom of the biblical monarch go against the clear meaning of the inscriptions and essentially function as arguments from silence. There is no temple of *Dwd*, no deity named Dod, and no urban center identified as "Beth-Dwd" known to scholars. These suggestions are flawed attempts to avoid the obvious implications of the name, which is that a real king named David ruled a small but important kingdom in the Levant and that the dynasty he founded continued to rule in Judah for many years after his death.

Ancient people were in a far better position to comment on the existence of the historical David than contemporary scholars. Inscriptions mentioning the "House of David" were carved when the Davidic dynasty still ruled in Judah. Modern authors are two and a half millennia removed from that time and have only limited evidence. Furthermore, the most vocal critics exhibit easily-detected prejudices against the biblical text. Although the references to David's dynasty do not mention specific events of his life, they do indicate that the ancients saw him as a historical figure.

Scholars make no attempt to discover the birthplaces of Uther or Merlin. They do not search for Avalon or try to determine where Arthur held court at Camelot. Excavators do not entertain any notions of finding the remains of the Round Table or the stone that held the fabled Excalibur. All of these things are the stuff of fantasy. By contrast, archaeologists can identify the town of David's birth, excavate the city where he ruled, and read his name in ancient inscriptions. Unlike the legendary king of the Britons, scholars have convincingly shown David to be a man of history. To argue otherwise says less about the Israelite king and more about the biases of the modern critic.

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## ENDNOTES


[1] K.A.D. Smelik, trans. (2000), "The Inscription of King Mesha," in *The Context of Scripture*, ed. William W. Hallo and K. Lawson Younger (Leiden: Brill), pp. 137-138.

[2] See André Lemaire (1994), "'House of David' Restored in Moabite Inscription," *Biblical Archaeology Review*, 20:30-37.

[3] Thomas L. Thompson (2004), *The Mythic Past: Biblical Archaeology and the Myth of Israel* (New York: Basic Books), p. 204. See also Thompson (1995), "'House of David': An Eponymic Reference to Yahweh as Godfather," *Scandinavian Journal of the Old Testament*, 9:74.

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[5] Philip R. Davies (1994), "'House of David' Built on Sand: The Sins of the Biblical Maximizers," *Biblical Archaeology Review*, 20[4]:54-55.

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[9] Anson F. Rainey (1994), "The 'House of David' and the House of the Deconstructionists," *Biblical Archaeology Review*, 20[6]:47.

[10] Alan Millard, trans. (2000), "The Tel Dan Stele," in *The Context of Scripture*, ed. William W. Hallo and K. Lawson Younger (Leiden: Brill), pp. 161-162.

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[15] Gary A. Rendsburg (1995), "On the Writing *bytdwd* in the Aramaic Inscription from Tel Dan," *Israel Exploration Journal*, 45[1]:22-25.

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# Total Depravity?

**Dave Miller, Ph.D.**

THE Calvinistic doctrine of Total Depravity maintains that all men have inherited the sin of Adam through their parents. As such, they are morally unable to choose to follow God and be saved because of their own depraved, sinful nature, which extends to every part of their personality. Hence, according to this doctrine, at birth—even prior to birth while still in the womb—every person is stained by Adam's sin and in a lost condition. This distorted thinking led to the necessity of infant baptism in order for a child to be cleansed of Adamic sin, which allegedly adheres to the soul.

Contrary to such thinking, the New Testament plainly disputes the notion of Total Depravity. In the first place, Paul clarified the onset of sin in every human being. Using himself as a prototype, he explained:

> ...I would not have known sin except through the law. For I would not have known covetousness unless the law had said, "You shall not covet." But sin, taking opportunity by the commandment, produced in me all manner of evil desire. For apart from the law sin was dead. **I was alive once without the law**, but when the commandment came, sin revived and I died. And the commandment, which was to bring life, I found to bring death. For sin, taking occasion by the commandment, deceived me, and by it killed me (Romans 7:7-11).

Paul remained uncondemned and unspotted by sin while in the womb and thereafter following his birth. He recognized that he was not guilty before God prior to the point at which he could understand God's commandments and realize his amenability to keep them. Prior to that point, he was too spiritually immature to be responsible for his actions.

The term rendered "revived"[1] does not mean that sin existed previously and then reasserted itself. Taking "revived" in that sense would mean that Paul had a period in between that was sinless—which does not support the notion of Total Depravity. When would that have been?

Instead, Paul was saying that, prior to his coming to a realization of his sin and the application of God's law to his life, he was not amenable to God's law and, therefore, not counted sinful by God: "for where there is no law there is no transgression" (Romans 4:15). Practically speaking, for children there is no law—except the law of their parents. Though children may violate God's law, e.g., lie to their parents, God's laws do not apply to children until they reach an age of accountability.[2] At that point, children reach a level of spiritual matu-

rity and become responsible before God for their behavior.

These observations lead us to draw this conclusion: the very idea that our spirits, in the womb and in post-birth infancy, are stained with sin is an indictment of God's justice, impartiality, and infinite goodness. Yet, the following biblical affirmations contradict the notion of Total Depravity and exonerate God for such injustice:

1. Solomon forthrightly declared that **our spirits came from God Himself** (Ecclesiastes 12:7).
2. This bestowal occurred at conception: "Thus says the LORD, who stretches out the heavens, lays the foundation of the earth, and **forms the spirit of man within him**" (Zechariah 12:1; cf. Hosea 9:11; Luke 1:36).[3]
3. When Paul addressed the Athenian philosophers on Mars Hill, he declared: "for in Him we live and move and have our being.... Therefore, since **we are the offspring of God...**" (Acts 17:28-29).

**Conclusion**: Since our spirits came directly from God at conception, making us the offspring of God, to suggest that the human spirit in the womb and at conception is stained with the guilt of Adam's sin makes God guilty of **creating** depraved human beings. But the Calvinistic doctrine of Total Depravity is incorrect. All human beings begin life with a spirit from God that is pure and clean.

## ENDNOTES

[1] ἀνέζησεν from αναζάω can mean "to revive, in the sense of to become vigorous" and "Metaph. to live a better life"—Charles Robson (1839), *A Greek Lexicon to the New Testament* (London: Whittaker & Co.), pp. 25-26.

[2] Dave Miller (2002), "The Age of Accountability," https://apologeticspress.org/the-age-of-accountability-1202/.

[3] For a discussion of the commencement of life, view this video: Dave Miller (2023), "When Does Human Life Begin?" https://apologeticspress.org/video/when-does-human-life-begin/.

# A Logical Argument for Literal Days of Creation

**Dave Miller, Ph.D.**

PREMISE 1: If the "days" of Creation in Genesis 1...
(a) are defined as an "evening" and a "morning,"
(b) are preceded by cardinal or ordinal numbers,
(c) are characterized by alternating periods of "day/light" and "night/darkness" (which facilitated photosynthesis, photoperiodism, and pollination),
(d) are mentioned alongside of "years" (and thus one can understand the difference),
(e) require symbiotic relationships among species created on separate "days,"
(f) entailed the creation of man and woman "from the beginning of the creation" who then witnessed the things God created "since the creation of the world,"
(g) and are identified by God/Moses as "six days" followed by the "seventh day" as the day of Sabbath rest,
**Then** the "days" of Creation in Genesis 1 were literal, 24-hour days.

PREMISE 2: The "days" of Creation in Genesis 1...
(a) are defined as an "evening" and a "morning" (Genesis 1:5,8,13,19,23,31),
(b) are preceded by cardinal/ordinal numbers (1:5,8,13,19,23,31),
(c) are characterized by alternating periods of "day/light" and "night/darkness" (1:3-5),
(d) are mentioned alongside of "years" (1:14),
(e) require symbiotic relationships among species created on separate "days" (e.g., yucca plant/yucca moth; Emerald Wasp/cockroach; Leafcutter ant and fungus; etc.),
(f) entailed the creation of man and woman "from the beginning of the creation" (Mark 10:6) who then witnessed the things God created "since the creation of the world" (Romans 1:20),
(g) are identified by God/Moses as "six days" followed by the "seventh day" as the day of Sabbath rest (Exodus 20:11).

CONCLUSION: Therefore, the "days" of Creation in Genesis 1 were literal, 24-hour days.

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